Counterfeit Glass Beads during the East African Caravan Trade: Mineralogical and Gemmological Analysis

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Abstract

This article presents results from mineralogical and gemmological analyses of imperfectly made tubular beads excavated at Kilwa Kivinje, a 19th century coastal caravan terminus in southern Tanzania. These beads are unique in size, their material, and colour, in addition to lacking treated cut ends. Because of their distinctive flaw, these beads required thorough laboratory analyses to determine how they compare to other glass beads from the same archaeological context. Although 19th century European travellers' accounts insist on glass beads being the popular commodity during the East African caravan trade, mineralogical and gemmological analyses revealed some of these beads to have been crafted from low-grade non-glass material. This prevented their standardisation in cut lengths, the permanency of coated colours, and the cut-ends treatment. These results justify speculation that these were counterfeits designed to pass for the original glass beads, possibly due to limited supply amidst high demand and the rapidly changing customer tastes for the much sought-after glass beads in East Africa during the height of the caravan trade. This is the first archaeological study in the region to examine the quality of traded glass beads during the caravan trade for their authenticity in artistry and material.

Keywords:
Counterfeit glass beads, caravan trade, mineralogical analysis, Kilwa Kivinje, Tanzania
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Introduction

The last two decades have witnessed a spike in archaeological research on the nineteenth century East African caravan trade (e.g., Croucher and Wynne-Jones 2006; Biginagwa & Katto 2020; Biginagwa & Lane 2021; Lane & Coutu 2022), hitherto an almost exclusive topic for historians (e.g., Beachey 1967; Baidelman 1982; Sheriff 1987; Koponen 1988; Alpers

1992; Kjekshus 1996; Rockel 2000). The archaeological intervention in this topic is helpful in revealing value-adding material evidence, which is crucial in grasping key aspects of the trade that do not feature sufficiently in most of the documentary records historians usually consult. Such material evidence has also proven to be a game-changer in cross-examining some previously unchallenged narratives ('received wisdom') about some aspects of the caravan trade, most of which derived from colonial archives (Leach & Mearns 1996). For instance, archaeologists have recently generated material evidence informing how locals navigated the throes of the slave trade in East Africa by periodically shifting their dwellings to hard-to-reach locations (Biginagwa & Mapunda 2017; Kusimba & Kusimba 2017), and how settlements of local communities in the interior realigned from time to time to capitalize on opportunities, on one hand (Mapunda 2004; Biginagwa & Ichumbaki 2018), and evade threats brought by the trade, on the other (Marshall & Biginagwa, *in press*).

Moreover, archaeologists have unearthed ecofactual evidence of how caravan trade impacted the food production systems of local communities along trade routes (Mgombere 2017; Biginagwa & Lane 2021). The emerging application of bioarchaeological techniques has also proven useful in determining ivory extraction source areas during the caravan trade (e.g., Coutu et al. 2016), which adds to the discussion about the environmental impacts of mass killings of elephants in those areas (Steinhart 2000; Håkansson 2004). In this regard, Thomas Håkansson (2004, p. 573) has argued convincingly that the massive loss of elephants, estimated to have been between 6,000 and 12,000 individuals per annum during the peak of the ivory trade, stimulated rapid recovery of woody vegetation, which in turn attracted tsetse flies—the disease vector for sleeping sickness and trypanosomiasis—and thereby discouraged pastoral activities.

It is important to note that some of the outlined issues were (and some are still) fiercely contested among writers on this topic before archaeological interventions. For instance, while Helge Kjekshus (1996) contends that the ecology and subsistence economy of most of the region's indigenous peoples suffered less from the caravan trade and more because of population growth, Juan Koponen (1988) and Thomas Håkansson (2004) have raised strong objections to this idea, arguing, instead, that much of the pre-colonial subsistence economy underwent rapid change during the 19th century because of the expanding coastal caravan trade. Implicitly, even though historical studies on this topic have tapped into the vast body of archival sources and oral histories, the details and specific relevance of information available on some aspects of the caravan trade are far less reliable before c. 1850 AD due to scarcity of written records. Thus, archaeology intervenes to contribute to this topic with tangible evidence. An additional advantage of archaeology is its ability to penetrate deep into time, far beyond documented history and human memory (Mapunda 1991).

This paper is another contribution of archaeology to a better understanding of the 19th century East African caravan trade. It unravels counterfeits hitherto treated as genuine glass beads that penetrated the markets during the peak of trade because of soaring demand. This topic does not feature adequately in the historiography of the caravan trade in East Africa. Particularly, the paper presents the mineralogical and gemmological analysis results of suspected counterfeit glass beads to inform how they differ in quality from the genuine glass beads they were retrieved together with from Kilwa Kivinje (Biginagwa 2014), which is one of the 19th century coastal caravan terminuses in East Africa (Rockel 2006; also see Figure 1).

Figure 1: Map of Tanzania shows the location of Kilwa Kivinje and other places covered in the text

This paper has eight sections. The subsequent section two scans over a brief history of the East African trade in glass beads. Section three describes the manufacturing processes of tubular glass beads to account for some key attributes of genuine glass beads essential to determining the authenticity of those discussed in this paper. Section four presents a short history of Kilwa Kivinje before the studied bead sample and the methods applied are described in Section five. Section six entails the analysis results, followed by the discussion in Section seven. Section eight concludes the paper.

Glass Bead Trade in East Africa

Glass beads have been part of the main trade cargoes brought to East Africa from various parts of the world in the last 2000 years (Freeman-Grenville 1962; Horton & Middleton 2000). In addition to their aesthetic appeal, glass beads symbolise prestige, spirituality, and protection in many African communities (Biginagwa 2012; Walz 2015; Moffet & Chirikure 2016). These cultural values are mostly conveyed through beaded frames, which also improve the painting's aesthetic appeal during socio-cultural gatherings.

Glass beads feature in various nomenclatures in the Greco-Roman travellers' documents, for example, the *Periplus of the Erythrean Sea* (ca. AD 100), *Ptolemy's Geography* (ca. AD 150), and in the writings of the Greek merchant Cosmas Indicopleustes (AD 547), as precious item traded in *Azania* (East African coast) for various use by locals (Horton and Middleton 2000). Since then, glass beads have been exchanged for local African commodities such as ambergris, ivory, rhino horns, tortoise and nautilus shell, coconut oil, and several other items whose names have yet to be translated (Freeman-Grenville 1962). In the first two documents above, *Rhapta* (named after its sewn boats) is mentioned as the mainland market located somewhere on the coast of East Africa and where overseas traders met locals for exchange (Casson 1989).

Between 800 and 1500 AD, overseas trade expanded rapidly out of eastern Africa to markets all over the world (Beachey 1967; Sherrif 1987). Subsequently, Swahili settlements along the coast expanded during this period (Horton & Middleton 2000; Fleisher 2010). Archaeological excavations at several coastal Swahili settlements such as Kilwa and Shanga confirm substantial trade between the coast and the East African interior by the 10th century, with coastal societies supplying beads, textiles, and iron tools in exchange for ivory, gold, copper, and cereals from the interior (Horton & Middleton 2000). During this period, glass beads originated mainly from Sri Lanka, India, and Iraq (Wood 2019), and during the 15th century, a few glass beads came from China (van der Sleen 1958). By the beginning of the second millennium AD, trade glass beads had reached the interior, as far as Lake Nyasa (Lupilo) region in what is now southwestern Tanzania (Biginagwa et al. 2021), as well as at the early centres of civilisation and economic power such as Great Zimbabwe (Chirikure et al. 2020), Mapungubwe, and Mgundgundlove/K2 (Moffet and Chirikure 2020). Gateways for glass beads from the outside world to interior African centres were coastal urban centres such as Kilwa Kisiwani, Sofala, and Chibuene (Chittick 1974; Wood 2015; Moffet and Chirikure 2016).

In the 16th century, European glass beads came to East Africa through the Portuguese (Wood 2012; Pallaver 2016). Initially, these beads were made to resemble glass beads already popular in the market (Koleini et al. 2019), particularly those from India (Wood et al. 2009). The main sources in Europe included Bohemia for Czech beads and Holland and Italy for Venetian beads (Wood 2002; Kimura & Shenkere 2009; African Beads and Fabrics 2023). These beads are also known as "trade beads" because they were used as legal tender in the 19th century to buy food, elephant ivory, and slaves, and for paying taxes and the caravan porters (Pallaver 2007). Documentary sources show that during the 19th century ivory and slave caravan trade glass beads were the second most sought-after item, just after cloths (Pallaver 2007). Coastal traders travelling to the interior to collect ivory, slaves, and other raw materials needed in the industrialising Western world bought beads from the Banyan traders in Zanzibar where, according to Richard Burton, they (glass beads) were imported from Europe "yearly by the tonne" (Burton 1859, p. 454).

Europeans travelling through East Africa during the peak of the caravan trade in the mid-19th century reported some popular glass beads in circulation. Among them imitate those retrieved from Kilwa Kivinje, known generically in Zanzibar as *hafiz*. Richard Burton described this type as "coarse porcelain" of various colours and "staples of commerce" (Burton 1860, pp. 393–4). Henry Morgan Stanley recorded the name *Sofi* for the same bead and described them as resembling "bits of broken pipe stems, about two-thirds of an inch in length, and white, brick-red, or blue in colour" (Stanley 1899 cited in Harding 1962, p. 177). Burton (1860) recorded three sub-types of *hafiz* beads that circulated in East Africa during his visit—*Kanyera*, *Merikani*, and *Kidunduguru*.

Kanyera referred to white cylindrical beads (also known as "oyster white"), or "ushanga waupa [mweupe]" in Kiswahili (Harding 1962, p. 105). According to Burton (1860, pp. 393–4), this variety was common throughout East Africa because it was cheap and plentiful, with six dollars per frasilah (about 16.32 kg) being the average price in Zanzibar. *Merikani* was a barrel-shaped and white *hafiz* sub-bead named after the white cloth imported from America that doubly served as currency in the hinterland. *Merikani* beads were common in Usagara, Ugogo, Unyamwezi, Ufipa, and Ujiji (Burton 1860, p. 394). In Ujiji, indigenous people sometimes threw these beads into the waters of Lake Tanganyika and local rivers to appease the 'Gods' and cross these water bodies safely (Stanley 1872). Burton also recorded the name *Kidunduguru* for the "dull brick-red" beads, about 4mm in diameter, which were sold in Zanzibar for five to seven dollars per frasilah (Burton 1860, p.393).

Travellers' accounts (e.g., Burton 1859; Burton & Speke 1858; Krapf 1860; New 1875) also reported how the tastes of local consumers rapidly evolved. In his detailed expedition report, *The Lake Regions of Central Equatorial Africa*, Richard Burton provides a glimpse into the dynamics of glass bead consumerism in East and Central Africa:

> Beads are a necessary evil to those engaged in buying ivory and slaves. In 1858 the Wajiji rejected with contempt the black porcelain, called *ububu*. At first, they would not receive the *khanyera*, or white porcelains; and afterwards, when the Expedition had exchanged, at a considerable loss, a large stock for *langiyo*, or small blues, they demanded the former. The bead most in fashion was the *mzizima*, or large blue glass, three *khete* or strings of which were equivalent to a small cloth; the *samesame*, or red corals, required to be exchanged for *mzizima*, of which one *khete* was equivalent to three of *samesame*. The *maguru nzige*, or pink porcelains, were at par. The tobacco-stem bead, called sofi, and current at Msene, was in demand. In exchanging others for this variety, the merchants lose considerably when by wear or accident the single pieces, called *masaro*, have diminished in size. The reader will excuse the prolixity of these wearisome details; they are necessary parts of a picture of manners and customs in Central Africa. Moreover, a foreknowledge of the requirements of the people is a vital condition of successful exploration. (Burton 1859, pp. 227-8)

Burton further noted that "failure to learn quickly as to what was required in the interior could lead to significant losses because unwanted commodities would simply not be purchased" (Burton 1859, p. 262). As a result, coastal traders and manufacturing firms in Europe had to adapt to the resulting local market dynamics (Prestholdt 2004). One strategy required caravan traders to carry merchandise of various sizes, shapes, and colours, depending on the predetermined needs in the interior markets. The caravan traders also had to redesign trade items into desirable forms, styles, and quantities either at East African trade centres or during the caravan routes before exchanges at local markets (ibid.). For example, before entering Maasailand, the Teleki expedition had to re-thread beads in 20 or 21-inch [50.8–53.4 cm] lengths to boost their acceptability and marketability (Prestholdt 2004, p. 766).

This article contends that local trade dynamics likely encouraged unscrupulous traders to introduce counterfeit glass beads. Indeed, records indicate that demand for glass beads peaked drastically during the 18th and 19th centuries because of the soaring demand worldwide, particularly in Africa (DeCorse et al. 2003) and the Americas (Sofia 2021). Large European companies stationed in Zanzibar to trade ivory were the main importers of European glass beads in East Africa, the notable ones being Hansing and Company, Wiseman and Company, and Meyer and Company (Beachey 1967). They supplied glass beads to Indian traders in Zanzibar, from whom they, in turn, purchased ivory for the world markets (Beachey 1967, p. 277). The ensuing section details the manufacturing processes of standard European-drawn glass beads and their characteristics to help distinguish between counterfeits and genuine glass beads.

Glass Beads Manufacturing Processes

The manufacturing of standard Venetian tubular glass beads in production centres in Italy required silica, fluxes, colourants, decolourants, and opacifiers (Blair 2015). According to Verita (2013), Venetian glassmakers used highly pure sources of quartz sand from the Ticino and Adige rivers in northern Italy. Flux was the material used to reduce the melting temperature of the silica (Blair 2015). Glass manufacturers used soda flux, which consisted of plant ash produced by burning glasswort, or barilla plant (Neri 2003). After preparation, the silica and flux were mixed into a batch and heated in a low-temperature fritting furnace. The solid frit was then broken apart and stored for later use (Blair 2015). To convert the frit into glass, one had to mix it with cullet, with broken scrap glass facilitating the melting of the batch, before placing it in a crucible in the primary furnace to stir it and add predetermined colourants, decolourants, and opacifying agents (McCray 1999).

After the glass was made, the next step was to transform the raw glass into a malleable form that could be made into beads. A hollow glass cane was required for making drawn beads (Francis 1988). A group of glass was heated, an opening was formed, and then two workers, walking in opposite directions, stretched the glass into a long, hollow tube, which was then allowed to cool, and the cane was broken into metre-long pieces (Karklins and Adams 1990). These lengths were then given to beadmakers for final processing, often outside the glass factories (Trivellato 1998). At the bead maker, the manufacturing process involved cutting the glass cane into short segments before rounding the cut ends into finished beads (Karklins and Adams 1990). Cutting was done by placing the tubes on a sharp broad chisel set on a bench or block of wood and striking it with another similar blade (Karklins 2012). However, in 1822, a mechanical tube-cutting machine was invented to increase the speed and efficiency of this task (Karklins & Adams 1990).

There were two methods of rounding the cut bead segment: rounding by heat in a copper pan called *a ferrazza*, or cut-glass segments threaded on a multipronged spit and then rotating in a furnace until rounded, known as *a speo* (Karklins 1993; Neri 2004). After the beads were rounded using either method, they were sorted by size and polished (Karklins & Adams 1990; Ninni 1991; Trivellato 1998). Finished beads were transported either as strands or in large quantities, loose in boxes or barrels (Bruseth & Turner 2005). Karklins (2012, p. 64) describes certain characteristics of drawn glass beads, which include bubbles in the glass, parallel-sided perforation with a smooth surface, a slight projection at one end (when rounded using the *speo* method), and/or a scar where two beads were fused but were later broken apart.

Blair (2005) points out that understanding each bead-making phase requires careful analysis of individual beads and bead assemblages. Each of the steps and patterns described depended on how each technological process was completed and revealed much about the network or location where the task was performed (Minar 2001). For example, the process of cutting glass canes into short bead lengths by the hands of a novice can leave distinct imperfections on the beads, particularly angles at one or both ends of the cut tube (Francis 2002). In this context, Blair (2005) submits that such variations depend on how the person cutting the canes holds and manipulates the glass cane and the cutting device. An inexperienced bead cutter could produce non-standard lengths of beads, some with slanted sharp edges (Francis 2002). As this article will further illustrate, Neri (2004) states that the analysis of both morphological and geochemical bead characteristics can distinguish beads from different producers or modifiers. The ensuing section provides a brief history of Kilwa Kivinje where the beads under study were retrieved.

A Brief History of Kilwa Kivinje

Kilwa Kivinje, literally meaning 'Kilwa of the Casuarina trees', is located in the northern part of the Kilwa peninsula, about 30km north of Kilwa Masoko. A large part of this town's history goes back to the 18th and 19th centuries AD (URT 2006) and is linked to the decline of the two formerly prosperous city-states of Kilwa Kisiwani and Songo Mnara, as well as the emergence of the caravan trade in elephant ivory and slaves (Chittick 1974; Biginagwa 2015). By the 1840s, Kilwa Kivinje was already the most important port and trading centre in the region, having absorbed many of the inhabitants of the two collapsed city islands (Biginagwa 2015). Kilwa Kivinje grew rapidly due to the lucrative ivory and slave trade that flourished during the 19th century, as the town became a major transit port for the southern caravan route, serving in that capacity a wider hinterland region of what is today southern Tanzania, northern Mozambique, the whole of Malawi and northern Zambia (Nicholls 1971). The geographical location of Kilwa Kivinje was advantageous for the caravans, especially the presence of the River Matandu (at about 5km north of Kivinje town), with its source at about 250km inland, exactly in the direction of Lake Nyasa where most slaves and ivory were collected during the 19th century (Biginagwa & Mapunda 2017). This river allowed the caravans to easily find water and also food from communities situated along it (Farler 1882).

The population of Kilwa Kivinje grew very fast due to the town's role as the ivory and slave caravan terminal. Krapf (1860) estimated the population of the town to have reached 15,000 inhabitants in 1844, and just four years later [1848], the population had reached 50,000 people. Kilwa Kivinje was the departure point for the caravans to the Lake Nyasa region. Led by the

Arabs, the Yao, and the Bisa, the caravans left Kivinje in March and came back in November (Krapf 1860), spending almost thirty days to reach Lake Nyasa (Lyne 1905). In the 1840s, there were about forty caravans in a year, each with about 8,000 to 10,000 slaves and about 4,000 to 5,000 elephant tusks brought to Kilwa Kivinje (Nicholls 1971). From 1862 to 1867, a total of 97,203 slaves had already been exported from Kilwa Kivinje, among whom 76,703 were deported to Zanzibar (Lyne 1905). In 1873, the slave trade, which was the backbone of the town's economy, was declared illegal and in 1889 all slaves at Kilwa Kivinje were set free (Nicholls 1971).

The later history of Kilwa Kivinje concerns the establishment of colonial rule. In 1891, the German colonial administration was established in southern Tanzania and the first governor was installed in Kilwa Kivinje, which became the administrative centre for the entire southern province, today covering the regions of Lindi and Mtwara (Iliffe 1979). Today, Kilwa Kivinje is marked by several historical buildings aligned in well-planned streets that testify to its history. Most of the buildings are ruined coral houses known to have been owned by the Indians, Arabs, and Swahili caravan traders (Figure 2). There are also German colonial buildings built using coral stones and coral lime mortar, with floors supported by mangrove beams (Bowen 1984). The Germans introduced some European elements to some buildings they inherited, including metal beams, square wooden beams, and wooden floors (Bowen 1984). Some elements of Swahili architecture, such as flat roofs (although these have been covered today with iron sheets) and merlons, which were used for decorating the roofs, are also evident in the ruined architecture of the town. The following section describes the studied bead sample and the methods employed.

Figure 2: A section view of Indian Street at Kilwa Kivinje. Author's photo, 2018

Material and Methods

This study focused on 114 tubular beads deemed unique by their length, imperfect cuts, untreated cut ends, and colour (Figure 3a), identified from a total of 532 excavated beads (Biginagwa 2015). These beads were among several cultural materials the author originally excavated in 2013 as part of his historical archaeology research project, which sought to reconstruct the history of Kilwa Kivinje in connection to the 19th century ivory and slave caravan trade. About 95 percent of all the recovered beads are tubular or cylindrical. All these beads were excavated from 19th century archaeological contexts, with five excavation units dug in the core area of the town.

Sample preparation and physical examination

All 114 distinctive beads (21.4% of the total recovered) were first cleaned by soaking them in distilled water for 30 minutes and then left to dry for 12 hours at room temperature on silver-coated plates. The aim was to clean them to allow visibility for physical examination. This task was executed at the University of Dar es Salaam's archaeology laboratory by the author. The samples were then examined physically, including measuring their sizes, determining their colours and colouration styles, and establishing whether their end cuts were treated or not. A Munsell colour chart and a simple binocular microscope were used in this task. To facilitate the initial examination of the raw materials, these beads were fractured at the epiphysis and scraped with dental picks. Both the fractured sections and the untreated cut ends allowed access to the inner parts of these beads for the preliminary determination of raw materials. The remaining 418 glass beads deemed original (Figure 3b) also underwent the same processes, with the exception that only 50 (12%) of them—broken ones—were examined for their raw materials using the procedures described above. The glass composition of this sample was visible even without using a microscope.

Figure 3:
A) a sample of tubular glass beads deemed to be fake; and B) a

sample of glass beads deemed to be standard (note treated end cuts). Author's photo, 2023

Mineralogical and Gemmological analyses

The mineralogical and gemmological analyses were undertaken to determine both the similarities and differences in terms of mineral and non-mineral compositions of the two bead samples (Figure 3). This included the types of inclusions, the important microstructure, the material hardness, and other optical and physical properties. A total of six glass beads, divided into two categories, were submitted to the African Minerals and Geoscience Centre (AMGC) laboratory (an ISO 9001:2015 accredited laboratory) based in Dar es Salaam, Tanzania. The first sample category labelled 'fake glass beads' consisted of three broken beads weighing 5.35 grams. These specimens were of oyster white, blue, and Indian red colours. The second sample category labelled 'standard glass beads', also consisted of three beads weighing 4.07 grams and with similar colours as the 'fake beads.' Both samples were subjected to mineralogical, petrological, and gemmological analyses using X-ray diffraction, a polarized light microscope, hydrostatic balance, hardness tester, polariscope, refractometer, microscope, and dichroscope. The results of all these tests are presented in the next section.

Results

Physical examination

Physical examinations revealed that the raw materials used to make all the 114 suspected counterfeit beads are not glass. When the untreated cut ends and fresh breaks were scratched using dental picks, even with fingernails, chalky and grainy particles fell out. Some of the broken bead pipes and those with disappearing exterior colours reveal unique textures reminiscent of stripped sugar cane. As for the cut-end treatments, none of them had treated ends. Snaps and tiny, sharp tails are hallmarks of their cut ends, probably due to the raw materials from which these beads were made. In terms of bead size, the suspected counterfeit beads are extraordinarily long, some up to 5cm, making it difficult to imagine how they were strung and worn. The size of their counterpart standard glass beads ranges between 5mm (0.5cm) and 12mm (1.2 cm), as is the size of glass beads recovered from Ngombezi and Old Korogwe (Biginagwa 2012), the caravan halt settlements in northeastern Tanzania (Figure 1).

Notable examination results of colour and colouration are five key aspects. When all the beads were first soaked in water, cleaned, and displayed to dry before physical analysis, the colours of the fake beads remained pale, in contrast to the colours of the standard glass beads, which immediately brightened upon contact with water. Secondly, the outer layers of colours of fake beads are thin and gritty, unlike the thick and smooth layers of standard glass beads. Third, the colours of the fake beads were impermanent, scratchable, and easily dissipated once rubbed with fingers. Fourth, some broken fake beads revealed stains of colour inside the bead hole, suggesting later application after the bead pipe had already been made. Fifth, three fake beads were found to have multiple layers of different impermanent colours, suggesting attempts to recolour the beads. Taken together, all these suggest that the colouring of the fake beads may have occurred outside the bead-producing factory and simply required dipping the bead tube in low-quality colours.

Mineralogical and gemmological analyses

The analysis revealed distinct raw materials used to make standard glass beads and the suspected counterfeit ones. This is based on inclusions, microstructure, material hardness, specific gravity (relative density), and other optical and physical properties tested to account for differences between the two bead sample categories submitted to the laboratory. The mineralogical X-ray diffraction revealed the predominance of the alumina oxide (Al_2O_3) material in the alleged counterfeit beads by 90.5 percent (Table 1). These are fine coral or jet ceramic materials that are infused with ingredients such as fibres, shells, and bones. The remaining 9.5 percent are minor components, namely quartz, periclase, magnesite, and aragonite. In contrast, quartz silica (SiO_2) dominates by 98.4 percent of the material used to make standard glass beads, with minor components such as rutile, periclase, siderite, and calcite constituting less than two percent as indicated in Table 1.

The difference in the raw materials used for making the two categories of bead samples analysed also mimics the properties of their inclusions. When crushed and pulverised, the standard glass beads revealed conchoidal fractures with smooth and curved surfaces, in contrast to the irregular, splintery, brittle, and fibrous fractures observed in the counterfeit beads (Figure 4). Additionally, the standard glass beads revealed bubbles, again, a typical feature of the rapid cooling of glass during manufacturing (Figure

4). To assess the scratch resistance of the two categories of bead samples, Moh's hardness test was carried out and the results showed that the standard glass beads had a homogeneous hardness of 5, but the counterfeit beads varied between 3.0 and 3.5 points. Hence, standard glass beads are significantly harder than fake glass beads (Table 1).

Table 1: Mineralogical and gemmological analysis results

<table>
<tr><th rowspan="2">Sample ID</th><th rowspan="2">Spec. Weight</th><th rowspan="2">Spec. Gravity</th><th rowspan="2">Moh's Hardness</th><th rowspan="2">Diaphaneity</th><th rowspan="2">Fracture Pattern</th><th colspan="2">Mineral Components</th></tr>
<tr><th>Major</th><th>Minor</th></tr>
<tr><td rowspan="5">Sample 1
Fake Glass Beads

(n=3)</td><td>1.61 g</td><td>1.78</td><td>3.5</td><td rowspan="5">Opaque</td><td rowspan="5">Irregular, Splintery, Brittle, & Fibrous</td><td rowspan="5">Alumina (Al_2O_3)

90.5%</td><td>Quartz (SiO_2) 3.2%</td></tr>
<tr><td>1.53 g</td><td>1.72</td><td>3.0</td><td>Berlinite ($AIPO_4$) 2.2%</td></tr>
<tr><td rowspan="3">2.21 g</td><td rowspan="3">1.81</td><td rowspan="3">3.5</td><td>Magnesite (MgO_3) 1.5%</td></tr>
<tr><td>Periclase (MgO) 1.4%</td></tr>
<tr><td>Vaterite ($CaCO_3$) 1.2%</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">Sample 2
Standard Glass Beads

(n=3)</td><td>1.45 g</td><td>2.51</td><td>5</td><td rowspan="4">Translucent to transparent</td><td rowspan="4">Conchoidal with sharp edges</td><td rowspan="4">Quartz (SiO_2)

98.4%</td><td>Rutile (TiO_2) 1.0%</td></tr>
<tr><td>1.33 g</td><td>2.48</td><td>5</td><td>Periclase (MgO) 0.3%</td></tr>
<tr><td rowspan="2">1.29 g</td><td rowspan="2">2.53</td><td rowspan="2">5</td><td>Siderite ($FeCO_3$) 0.2%</td></tr>
<tr><td>Calcite ($CaCo_3$) 0.1%</td></tr>
</table>

Other tests performed in the laboratory include diaphaneity that measures the material's ability to transmit light, and specific gravity, or relative density, which indicates a material's level of purity. Table 1 reveals the differences, showing that standard glass beads have transparent material, while counterfeit glass beads have opaque material. In comparison, the density of standard glass beads is also higher than that of fakes.

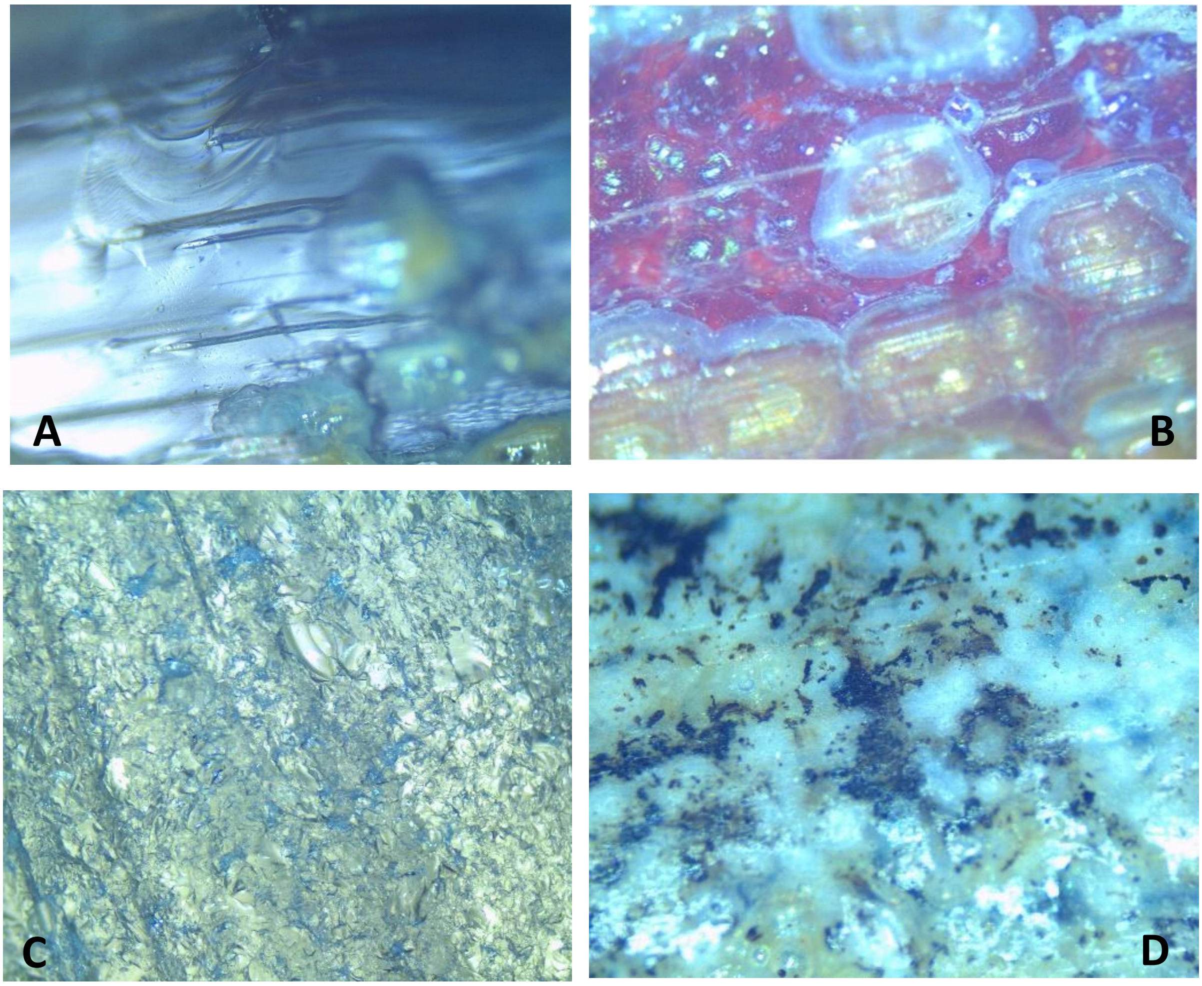

Figure 4: Photomicrographs of pulverised studied bead samples reveal various characteristics: A) conchoidal fracture (note the curved lines) typical for the glass material ('standard' glass bead sample, blue); B) bubble

inclusions in the glass material ('standard' glass bead sample, Indian-red; C) irregular splintery of non-glass material ('fake' glass bead sample, blue); D) heterogeneous material, no glass element ('fake' glass bead sample, oyster-white). Photos by Matokeo Simba (AMGC Lab, 2023).

Discussion

Previous studies have shown that alumina content may indicate the region from which the glass was made since these materials match the geochemistry of the area where the silica sources, whether crushed quartz or sand, originate (Wood et al. 2009; Dussubieux et al. 2010; Wang, Iizuka, & Jackson 2022). It has been found that granite sand generally produces glass in which the proportion of alumina is much higher than that of lime, while lime sand from coastal deposits results in glass with a higher proportion of lime than alumina (Wood et al. 2009). On the contrary, crushed quartz pebbles are a purer source of silica and produce glass with less lime and alumina oxide. Geochemical analyses of beads have confirmed that glasses from the Middle East and Europe have an alumina oxide (Al_2O_3) content well below four percent, while glasses from South and Southeast Asia have values between five and 20 percent (Wood 2011, p. 73). In addition, the high alumina concentration (more than 4%) was found to be related to granite sand, which usually contains relatively higher amounts of impurities, often referred to as mineral soda alumina (m-Na-Al) glass (Brill 2001). Plant ash beads, on the other hand, contain much less Al_2O_3 and less CaO, but more SiO2 (Wood 2011). In addition, Brill (2001) notes that the content of magnesia (MgO) can contribute to the separation of the two types of glasses: the MgO content in mineral soda glasses is $<2.5\%$, while in plant-ash glasses is generally $>2.5\%$.

Based on the analysis results in this article, it turns out clear that the beads thought to be standard glass beads are indeed made of pure glass obtained from quartz silicate, a typical raw material used to produce Venetian glass beads in production centres in Italy. However, it is well documented that alumina was another important ingredient in the production of glass beads (Dussubieux et al. 2010), as it improves the properties of soda-lime-silicate glasses and inhibits devitrification (Wang, Iizuka, & Jackson 2022). Nevertheless, the value of alumina oxide content recorded in the allegedly counterfeit glass beads under discussion is extremely high, up to 90 percent of the material composition. This figure is far above the normal recorded value for glass beads from south and southeast Asia, the place of origin of glass beads made from alumina. There is no denying that such an excess of alumina oxide makes these beads of significantly poor quality as this analysis revealed. In due regard, it remains difficult to conclusively confirm that they were made in south or southeast Asia.

So, where were these counterfeit glass beads made? It could be either in Kilwa Kivinje or in Europe. Dussubieux and Karklins (2016) report tubular beads of unusual length and untreated cut-ends as those discussed in this article from the seventeenth century sites of Hammersmith Embarkment in West London and 10 kg in Amsterdam. Although the reporters do not reveal the type and quality of raw materials used in manufacturing (to allow comparison with the counterfeit beads under discussion), they do provide two important observations that enrich this discussion: first, that those 'beads' are likely to be 'bead production wasters' and, second, that they usually occur at bead production sites. Storm and Karklins (2021) acknowledge the possibility that some 'bead wasters' can be accidentally exported to the markets along with well-made beads. Their observation leads this paper to speculate about the town of Kilwa Kivinje or nearby as the place of manufacture of what this paper terms counterfeit glass beads. However, additional research is required to establish this paper's speculation.

Nevertheless, the thesis posed above does not exclude the possibility that these counterfeits were also likely made in Europe. Bead researchers have reported that in the post-Middle Ages, other European countries such as England, Holland, Germany, and France began producing Venetian glass beads after they became increasingly popular (Dussubieux and Karklins 2016, p. 574). Venetian and Italian glassmakers had emigrated to different regions of Europe to practice this art, thus contributing to the spread of the then-Venetian glass bead-making technology (Maitte 2013). However, it is recognized that although Venetian and other European glass beads would be virtually indistinguishable, the use of different materials can be demonstrated through trace element analysis (Cagno et al. 2012). Unfortunately, such studies do not yet exist, which is why there is a lack of comparative data.

There appears to be two plausible explanations regarding why counterfeit glass beads were made. First, it may be that glass bead production in bead manufacturing centres in Italy failed to meet the growing market demand for glass beads worldwide. In other words, demand was higher than production and supply, so the market became vulnerable to manipulation including the supply of sub-standard beads a far-cry from the Venetian originals. The rapid growth of the market for aesthetically pleasing glass beads worldwide in the 19th century is acknowledged (DeCorse et al. 2003; Sofia 2021). Therefore, the demand was greater than what the channels available could produce; hence, consumers ultimately became vulnerable to being inundated with replicas.

Second, as European travellers reported that coastal traders were struggling to meet the demand for the rapidly changing tastes of various goods, this may have triggered the production of counterfeit glass beads locally to adapt to the rapidly changing fashions and tastes of local consumers. The local production of these beads from different materials, even if they were undoubtedly of lower aesthetic and material quality, might have allowed coastal traders to fake various aspects as the market dictated. Coastal traders would be able to quickly fabricate colours in high demand to capitalize on gaps in the supply of genuine, aesthetically pleasing beads. Future studies could attempt to determine the acceptability of those 'fake beads' in markets. However, in his research of the 19th-century caravan halt settlements of Ngombezi and Old Korogwe in northeastern Tanzania (Figure 1), Biginagwa (2012) was unable to identify those beads in his collection.

Nevertheless, manoeuvring with trade goods during the caravan trade was not just for beads. Travellers' accounts suggest similar attempts for other goods traded in East and Central Africa, such as cloth, which was highly valued as a commodity for acquiring the goods of the caravan trade (Pallaver 2009). Until the 1860s, the most commonly requested type of cloth was a type of unbleached cotton produced in Salem, Massachusetts in the United States, known in East Africa as *merekani* or *merikani* (literally "American"). This cloth dominated the East African market until the US Civil War (1861–1855), when cotton supplies to Salem ceased and traders introduced the inferior indigo-dyed cotton (from Bombay) made in India called *kaniki* (Prestholdt 2004, p. 773).

Redesigning commodities into desirable forms, styles, and quantities also emerged as another strategy for exploiting local tastes. In Unyanyembe, coastal artisans bought English broadcloth and converted it into the *kizibao* (waistcoat), which wealthy men desired (Prestholdt 2004). In the same area, local artisans fashioned imported wire into armlets, leg bracelets, bells, necklace beads, and rings, as well as inlays for gunstocks and knife hilts

(Prestholdt 2004). Apparently, even though imported goods such as brass wire, beads, and cloth were regarded as finished goods by manufacturers, in the case of East Africa these goods were treated as partially manufactured since they frequently required radical redesigns to meet the demands of the local market.

Conclusion

The results of this study not only reveal the existence of counterfeit goods traded during the 19th century caravan trade in East Africa, but they also highlight the importance of using archaeological methods to gain a deeper understanding of our recent past. We are constantly led to believe that historical studies relying on archival and oral sources adequately cover many aspects of our recent past. This may also explain why several studies on the glass bead trade in Africa pay more attention to the pre-European contact period to understand the materials from which these beads were made and to locate their origin. This work has focused on the 19th-century period and showed that not all beads traded during the caravan trade in East Africa were glass beads, as reported by European explorers travelling through the region during the height of the trade and subsequent historical studies of the caravan trade. Rather, some traded beads were made of a non-glass substance. When these beads were compared to those made from silica originating in quartz, they were found to be of inferior quality in numerous areas. This low quality is reflected in the typical defects of these fake glass beads, which include but are not limited to, inferior and transient hues, untreated cut ends, irregular bead lengths, and inconsistent colours. The study concludes that these imitated glass beads, known by the moniker of counterfeit (or fake) glass beads, were likely made outside the production centres of Venetian glass beads but to closely resemble the original variety. On the other hand, the falsification of trade products during the caravan trade reveals more about Africans' position and standing in the global economic system that ringed the Indian Ocean in the 19th century. In both scenarios, initiatives to forge traded commodities demonstrate how the voices of African consumers were being heard in international trade networks, whether to meet supply needs or adapt to the rapidly changing tastes of local customers.

Finally, the findings in this article reveal that trade in counterfeit ornaments is not as new as many may think. What happened in the past is the same thing that is happening in the markets now. Today, a wide variety of items are manufactured worldwide for a range of market-oriented purposes. In Tanzania, as in many other parts of the world, it is common to find genuine, high-quality goods in markets, usually sold at higher prices, or low-quality goods at lower prices. All of this is designed to accommodate customers of different levels of purchasing power. This article has opened up avenues for archaeological and material science interrogation of the various forms of traded goods during the caravan trade in the 19th century.

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